

## Real-Time Geo-Registration on High-Performance Computers

Alan Chao Monica Burke ALPHATECH, Inc. Thomas Kurien
Luke Cico
Mercury Computer Systems, Inc.

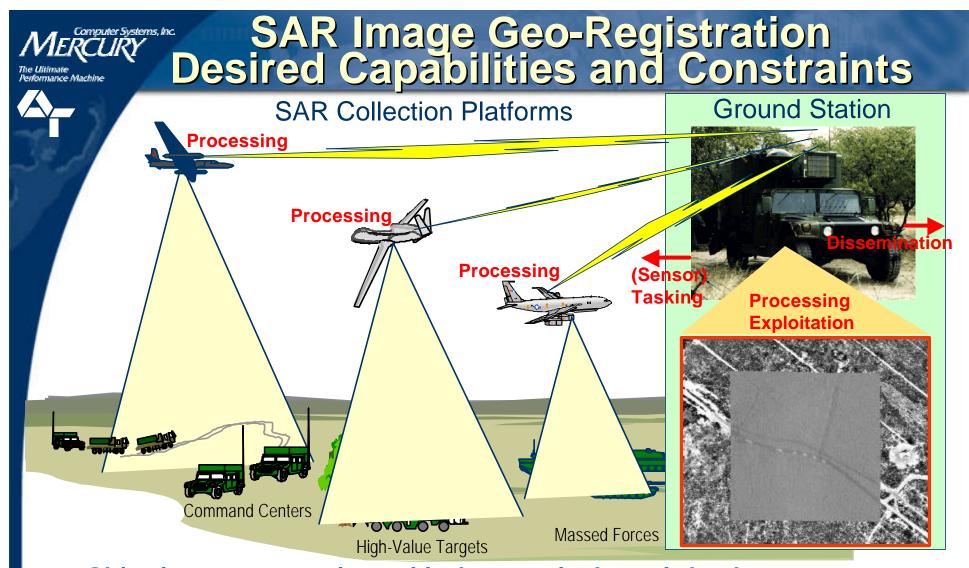
High Performance Embedded Computing Workshop - September 24, 2002

The Ultimate Performance Machine

maintaining the data needed, and of including suggestions for reducing	empletion of information is estimated to completing and reviewing the collect this burden, to Washington Headquuld be aware that notwithstanding an OMB control number.	ion of information. Send comments arters Services, Directorate for Information	regarding this burden estimate or mation Operations and Reports	or any other aspect of the , 1215 Jefferson Davis	is collection of information, Highway, Suite 1204, Arlington
2. REPORT TYPE N/A N/A			3. DATES COVERED		
4. TITLE AND SUBTITLE		5a. CONTRACT NUMBER			
Real-Time Geo-Registration on High-Performance Computers				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  Mercury Computer Systems, Inc.				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAIL  Approved for publ	LABILITY STATEMENT lic release, distributi	on unlimited			
13. SUPPLEMENTARY NO Also see ADM0014	OTES 173 , The original do	cument contains col	or images.		
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFIC	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON		
a. REPORT unclassified	ь. abstract <b>unclassified</b>	c. THIS PAGE unclassified	UU	13	ALSI ONSIBLE I ERSON

**Report Documentation Page** 

Form Approved OMB No. 0704-0188



- Objective: prosecute time-critical targets in dynamic battlespace
- Requirement: near real-time mensuration and geo-location of targets in collected SAR image
- Satisfy space, weight, and power constraints (airborne sensor platforms, mobile ground stations)
  © 2002 Mercury Computer Systems, Inc.



#### Signal and Data Processing



- Signal Processing
  - MTI report generation
  - SAR image formation

- Typically on collection platform
- Requires 100s of GFLOPS
  - Function of input data rate
  - Data independent
- Real time
- Data Processing (Data Exploitation)
  - Report processing
    - Registration
    - Target tracking
    - Multisensor report fusion
  - Image processing

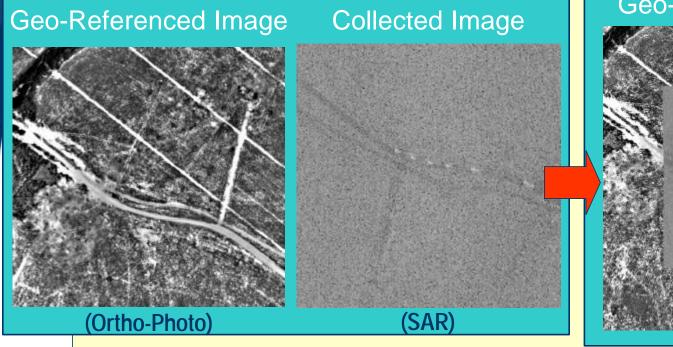
- Typically on ground station
- Requires 10 to 100 GFLOPS
  - Function of input data rate
  - Data dependent
  - Need to formulate multiple interpretations of data (perform search)
- Non-real time
   Real time
- Image-level (geo-registration, mosaicking)
- Chip-level (ATR)



#### Image Geo-Registration



 Objective: determine spatial correspondence between collected image and geo-referenced data



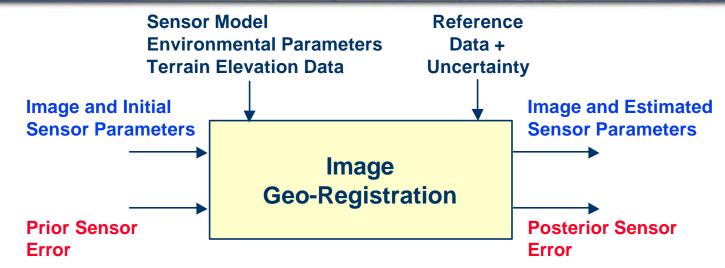


- Image geo-registration prerequisite for:
  - Target mensuration and geo-location
  - Change detection
  - Fusion of geometric/spectral information across images



#### Image Geo-Registration Approach





- Registration estimates the most probable location of an image relative to a reference.
- Two coupled sub-problems:
- Search Problem
- Feature selection and association: extracting salient features across data and computing the optimal correspondence between the two sets of features for a given set of image collection parameters.
  - ▶ Collection parameter estimation: computing the optimal image collection parameters for a given correspondence between the two sets of features.



### **Throughput Requirements**



#### Function of

- ▶ Feature- or intensity-based approach
- ▶ Features used (e.g., topological, region, object)
- Matching algorithm (e.g., Hausdorff distance, Bayesian metric)
- Desired accuracy

#### Preliminary Estimates

- Intensity-based algorithm for SAR image registration
- **▶** 1800 x 1800 pixel SAR image
- ▶ ~60 Giga operations
- High throughput driven by high-input rate and requirements for search
- Need multiprocessor implementation



### Mapping Approach



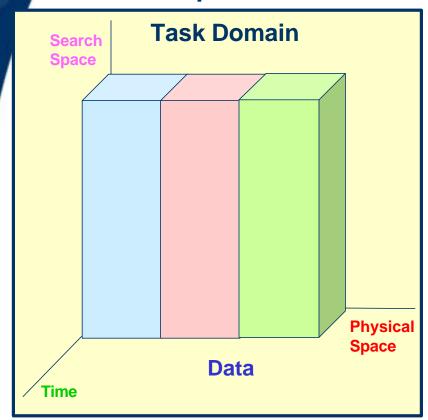
- General Techniques
  - Round-robin scheduling (process replication)
  - Pipeline processing (process partitioning)
  - Data parallel processing (process replication with partitioned data)
- Data Parallel Processing Applicable for Data Exploitation Algorithms
  - Partition data sets in either search or physical space
  - Select partitions requiring high throughput
  - Minimize processing latency by distributing parallel tasks over multiple processors
- Mapping of Image Registration Algorithm
  - Evaluation of match metric is compute-intensive
  - Match metric computation can be performed in parallel



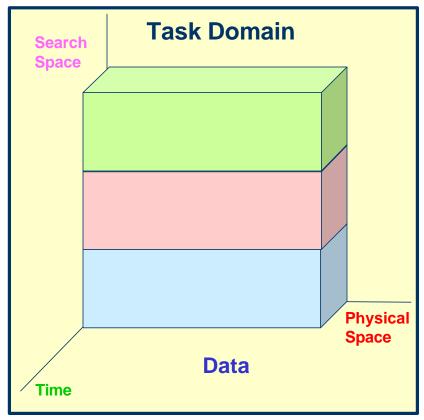
#### **Data Parallel Tasks**



- Data Exploitation Algorithms
  - Contain data-parallel tasks in both physical and search space



Data Partitions in Physical Space (e.g., MHT, ATR)



Data Partitions in Search Space (e.g., Registration)



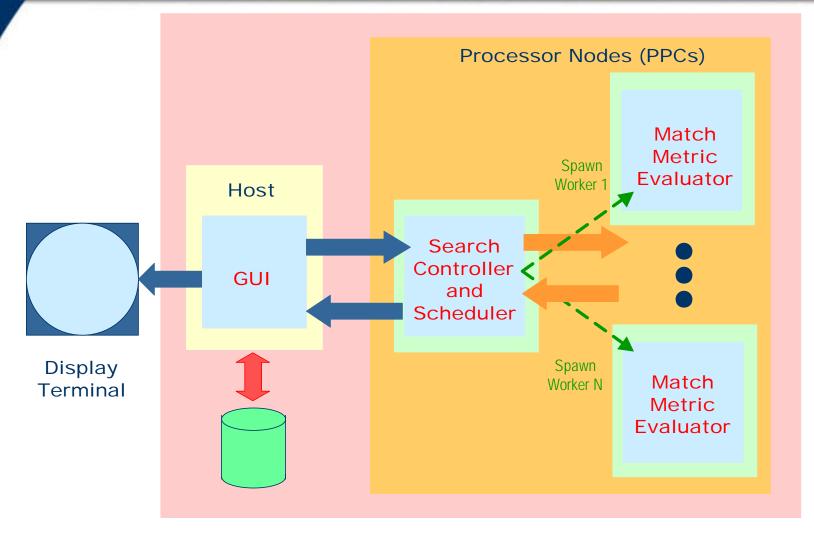
#### **Geo-Registration Implementation**



- Hardware: Mercury VME System
  - ▶ 1 host board containing host processor (GUI + I/O)
  - 2 6U boards containing 8 PowerPC processors (geo-registration algorithm)
  - RACEway Interconnect (ILK-4)
- Software
  - TcI/Tk (GUI)
  - ▶ C++ (geo-registration algorithm)
- Middleware
  - Efficient distribution of data and tasks to multiple processors, synchronization tools (currently using MPI; plan to use PAS™)
  - Efficient implementation of standard scientific and image processing functions on PowerPC (plan to use SAL and Pixl™)



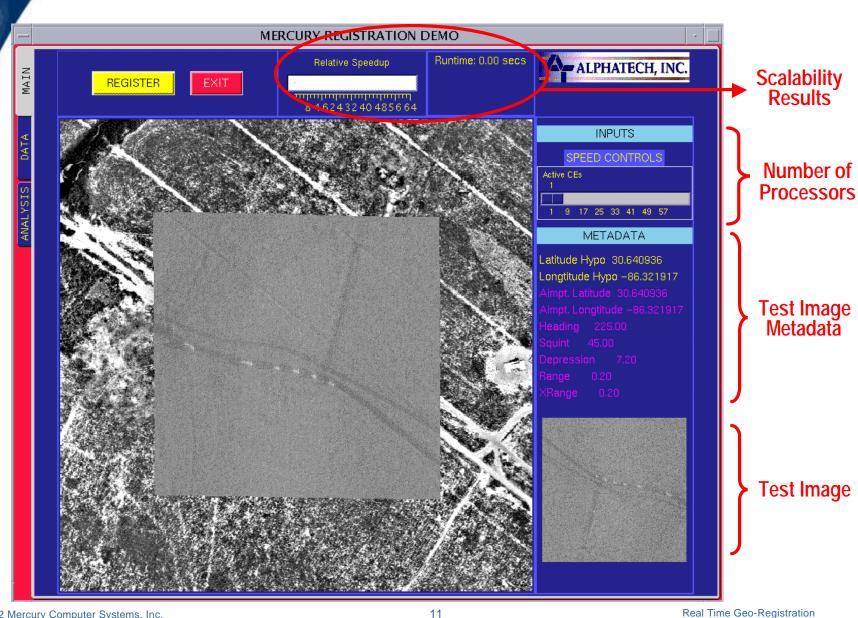
# Geo-Registration Implementation on Mercury System



Match Metric Evaluator: Mutual Information in Pixel Intensity Distributions



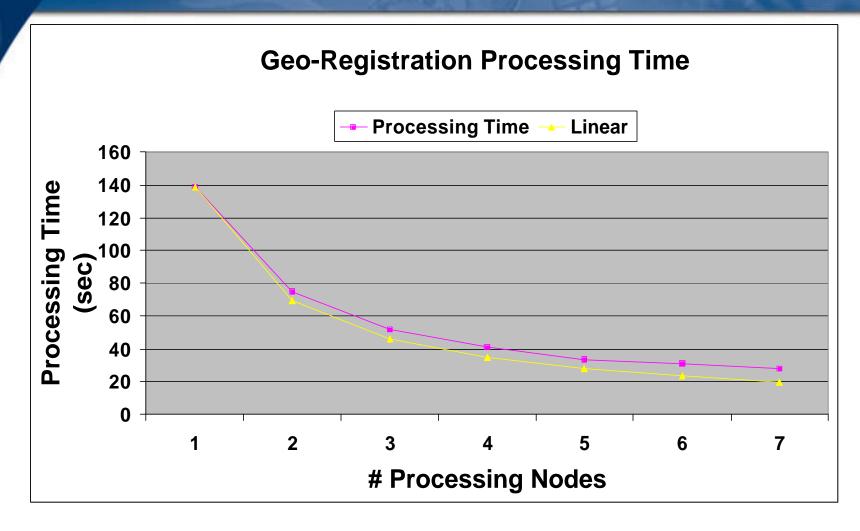
## Scalable Geo-Registration Algorithm: Demo Interface



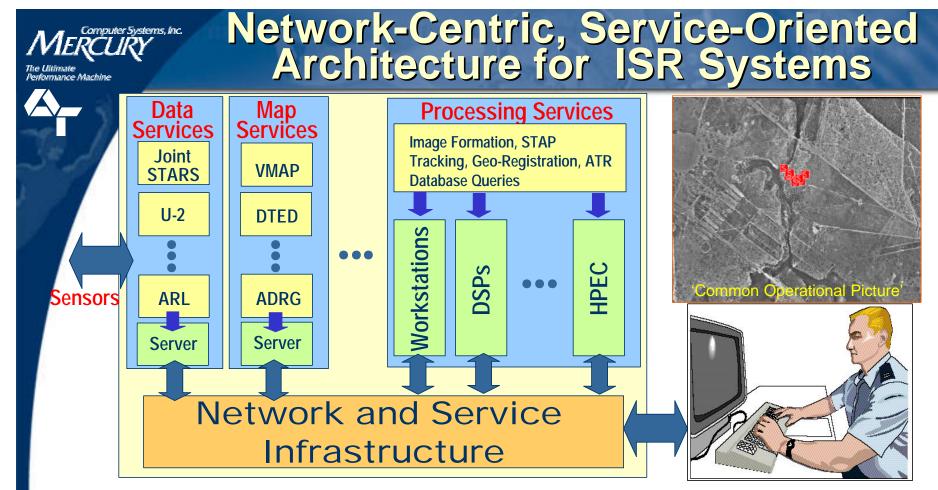


## **Computational Scalability**





- Implementation demonstrates close to linear scalability
- For 64-processor system: ~ 2.2 seconds (estimated)



- Role of High-Performance Embedded Computers
  - Provide multiple ISR processing services (STAP, Tracker, ATR, etc.)
  - Parallel algorithms enable the surveillance operator to specify desired QoS for each service
- Mercury/ALPHATECH Developing Scalable High-Performance Data Exploitation Algorithms for ISR Systems